CORE COURSES

SEMESTER - I

PH1CO1 MATHEMATICAL METHODS IN PHYSICS – I

Unit I

Vectors and Vector Spaces (18 Hrs)

Integral forms of gradient, divergence and curl, Line, surface and volume integrals – Stoke's, Gauss's and Green's theorems - Potential theory - scalar, gravitational and centrifugal potentials. Orthogonal curvilinear coordinates - gradient, divergence and curl in Cartesian, spherical and cylindrical coordinates. Equation of continuity - Linear vector spaces - Hermitian, unitary and projection operators with their properties- inner product space - Schmidt orthogonalization - Hilbert space - Schwartz inequality.

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4PthP Edition, Academic Press (Chapter 1 & 2)

2. Mathematical Physics, P.K Chattopadhyay, New Age International (chapter 7)

3. Theory and problems of vector analysis, Murray R. Spiegel (Schaum's outline series)

Unit II

Matrices (12 Hrs)

Direct sum and direct product of matrices, diagonal matrices, Matrix inversion (Gauss-Jordan inversion method) orthoganal, unitary and Hermitian matrices, normal matrices, Pauli spin matrices, Cayley-Hamilton theorem.Similarity transformation - unitary and orthogonal transformation.Eigen values and eigenvectors – Diagonalisation using normalized eigenvectors.Solution of linear equation-Gauss elimination method.Normal modes of vibrations.

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4PthP Edition, Academic Press (Chapter 3)

2. Mathematical Physics, P.K Chattopadhyay, New Age International (Chapter 7)

Probability theory and distributions (6 Hrs)

Elementary probability theory, Random variables, Binomial, Poisson and Gaussian distributions-central limit theorem.

Text Books

1. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press (Chapter 24)

2. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4PthP Edition, Academic Press. (Chapter 19)

Unit III

Differential Geometry(16 Hrs)

Definition of tensors, basic properties of tensors. Covariant, contravariant and mixed tensors. Levi-Civita tensor, Metric tensor and its properties, Tensor algebra, Christoffel symbols and their transformation laws, covariant differentiation, geodesic equation, Riemann-Christoffel tensor, Ricci tensor and Ricci scalar.

Text Books

1. Introduction to Mathematical Physics, Charlie Harper, PHI

2. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill T T

3. Mathematical Physics, B.S. Rajput, Y. Prakash 9PthP Ed, PragatiPrakashan (Chapter 10)

4. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press

Unit IV

Special functions and Differential equations (20 Hrs)

Gamma and Beta functions, different forms of beta and gamma functions, evaluation of standard integrals. Dirac delta function, Kronecker Delta - properties and applications. Bessel's differential equation – Bessel and Neumann functions – Legendre differential equation - Associated Legendre functions- Hermite differential equation - Laguerre differential equation – Associated Laguerre polynomials. (Generating function, recurrence relations, and orthogonality condition for all functions), Rodrigue's formula

Text Books

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4PthP Edition, Academic Press

2. Mathematical Physics, B.S Rajput, PragatiPrakashan

Reference Books:

1. Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi

2. Advanced Engineering Mathematics, E. Kreyszig, 7PthP Ed., John Wiley

3. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill

4. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill

5. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R. Harvill, Tata McGraw Hill

6. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House. 7. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

PH1C02 CLASSICAL MECHANICS

Unit I

Hamiltonian Mechanics (10 Hrs)

Review of Newtonian and Lagrangian formalisms - cyclic co-ordinates - conservation theorems and symmetry properties - velocity dependent potentials and dissipation function - Hamilton's equations of motion - Least action principle - physical significance.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3PrdP Ed., (Chap. 1, 2 & 8)

Variational Principle and Lagrange's equations (6 Hrs)

Hamilton's principle - calculus of variations – examples - Lagrange's equations from Hamilton's principle.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3PrdP Ed., (Chapter 2)

Unit II

Mechanics of Small Oscillations (6 Hrs)

Stable and unstable equilibrium - two-coupled oscillators – Lagrange's equations of motion for small oscillations - normal co-ordinates and normal modes - oscillations of linear tri-atomic molecules.

Text Book:

1. Classical Mechanics, S.L. Gupta, V. Kumar & H.V. Sharma, PragatiPrakashan, 2007. (Chapter 8)

Canonical Transformations (7 Hrs)

Equations of canonical transformation- examples of canonical transformation - harmonic oscillator.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3PrdP Ed. (Chapter 9)

Poisson brackets - Lagrange brackets - properties- equations of motion in Poisson bracket form - angular momentum Poisson brackets - invariance under canonical transformations.

Text Book:

1. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 7)

Hamilton-Jacobi Theory (7 Hrs)

Hamilton-Jacobi equation for Hamilton's principal function - harmonic oscillator problem - Hamilton - Jacobi equation for Hamilton's characteristic function- action angle variables in systems of one degree of freedom - Hamilton-Jacobi equation as the short wavelength limit of Schroedinger equation.

Text Books

: 1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3PrdP Edn. (Chapter 10)

2. Classical Mechanics, J.C. Upadhyaya, Himalaya, 2010. (Chapter 8)

Unit III

Central Force Problem (9 Hrs)

Reduction to the equivalent one body problem - equations of motion and first integrals - equivalent one-dimensional problem and classification of orbits - differential equation for the orbits – virial theorem - Kepler problem.

Text Book:

1. Classical Mechanics, H. Goldstein, C.P. Poole & J.L. Safko, Pearson, 3PrdP Ed.. (Chapter 3)

Rigid Body Dynamics (9 Hrs)

Angular momentum - kinetic energy - inertia tensor - principal axes - Euler's angles- infinitesimal rotations - rate of change of a vector - Coriolis force - Euler's equations of motion of a symmetric top - heavy symmetric top with one point fixed.

Text Book:

1. Classical Mechanics, G. Aruldhas, Prentice Hall 2009, (Chapter 8)

Unit IV

General Theory of Relativity (9 Hrs)

Principle of equivalence - principle of general covariance - motion of a mass point in a gravitational field - the Newtonian approximation - time dilation - rates of clocks in a gravitational field - shift in the spectral lines – energymomentum tensor- Einstein's field equations and the Poisson approximation.

Text Book:

1. The Theory of Relativity, R.K. Pathria, Dover Pub. Inc. NY,2003 (Chap 6,7& 8)

Classical Chaos (9 Hrs)

Linear and non-linear systems - integration of linear equation: Quadrature method - the pendulum equation – phase plane analysis of dynamical systems – phase curve of simple harmonic oscillator and damped oscillator- phase portrait of the pendulum - bifurcation - logistic map – attractors - universality of chaos - Lyapunov exponent - fractals - fractal dimension.

Text Book:

1. Classical Mechanics, G. Aruldhas, Prentice Hall 2009, (Chap.11& 12)

Reference Books:

1. Classical Mechanics, N.C. Rana and P.S. Joag, Tata McGraw Hill
2. Introduction to Classical Mechanics, R.G. Takwale and P.S. Puranik, TMGH.
3. Langrangian and Hamiltonian Mechanics, M.G. Calkin, World Scientific Pub.Co Ltd
4. Introduction to General Relativity, R. Adler, M. Bazin, M. Schiffer, TMGH.
5. An introduction to general relativity, S. K. Bose, Wiley Eastern.
6. Relativistic Mechanics, SatyaPrakash, Pragathiprakashan Pub.
7. Chaos in Classical and Quantum Mechanics, M.C.Gutzwiller, Springer, 1990.
8. Deterministic Chaos, N. Kumar, University Press,
9. Chaotic Dynamics, G.L.Baker&J.P.Gollub, Cambridge Uni.Press, 1996
10. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4PthP Edition.

PH1C03 ELECTRODYNAMICS

Unit I

Electrostatic fields in matter and Electrodynamics (10 Hrs)

Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell’s stress tensor. Electromagnetic waves (8 Hrs) Maxwell’s equations in phasor notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI.

Unit II

Relativistic Electrodynamics (18 Hrs)

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics - Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI

Unit III

Electromagnetic Radiation (20 Hrs)

Retarded potentials, Jefimenkos equations, Point charges, LienardWiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction.

Text Book:

1. Introduction to Electrodynamics, David J. Griffiths, PHI

Unit IV

Antenna, Wave Guides and Transmission Lines (16 Hrs)

Radiation resistance of a short dipole, Radiation from quarter wave monopole or half wave dipole.Antenna parameters. Waves between parallel conducting plane TE, TM and TEM waves, TE and TM waves in Rectangular wave guides, Impossibility of TEM waves in rectangular wave guides. Transmission Lines-Principles-Characteristic impedance, standing waves-quarter and half wavelength lines.

Text Books:

1. Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968

2. Antenna and wave guide propagation, K. D Prasad, SatyaPrakashan.

Reference Books:

1. Antennas, J.D Kraus, Tata Mc-Graw Hill.

2. Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.

3. Electromagnetic fields, S. Sivanagaraju, C. SrinivasaRao, New Age International.

4. Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.

5. Electromagnetic Waves and Fields, V.V. Sarwate, Wiley Eastern Ltd, New Age Inernational

6. The Feymann Lectures in Physics, Vol. 2, R.P. Feymann, R.B. Leighton & M. Sands.

7. Electronic Communication Systems, G. Kennedy & B. Davis, TMH.

PH1C04 ELECTRONICS

Unit I

Semiconductor Devices (5 Hrs)

FET devices - structure, characteristics, frequency dependence and applications

Text Book:

1. Fundamentals of Semiconductor Devices, Betty Anderson, Richard Anderson, TMH. (Chapter 7, 8 and 9)

Op-amp with Negative Feedback (13 Hrs)

Differential amplifier – Inverting amplifier – Non-inverting amplifier -Block diagram representations – Voltage series feedback: Negative feedback – closed loop voltage gain – Difference input voltage ideally zero – Input and output resistance with feedback – Bandwidth with feedback – Total output offset voltage with feedback – Voltage follower. Voltage shunt feedback amplifier: Closed loop voltage gain – inverting input terminal and virtual ground - input and output resistance with feedback – Bandwidth with feedback - Total output offset voltage with feedback – Current to voltage converter- Inverter. Differential amplifier with one op-amp and two op-amps.

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4PthP Edn. PHI, (Chapter 2 & 3)

Unit II

The Practical Op-amp (6 Hrs)

Input offset voltage –Input bias current – input offset current – Total output offset voltage- Thermal drift – Effect of variation in power supply voltage on offset voltage – Change in input offset voltage and input offset current with time - Noise – Common mode configuration and CMRR.

Text Book:

1. Op-amp and linear integrated circuits, R.A. Gayakwad 4PthP Ed. PHI. (Chapter 4)

General Linear Applications (with design) (12 Hrs)

DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing , Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Low voltage DC and AC voltmeter - Voltage to current converter with grounded load – Current to voltage converter – Very high input impedance circuit – integrator and differentiator.

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4PthP Ed. PHI. (Chap. 6)

Unit III

Frequency Response of an Op-amp (6 Hrs)

Frequency response –Compensating networks – Frequency response of internally compensated and non compensated op-amps – High frequency opamp equivalent circuit – Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate.

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4PthP Edn.PHI, (Chap.5)

Active Filters and Oscillators. (with design) (12 Hrs)

Active filters – First order and second order low pass Butterworth filter - First order and second order high pass Butterworth filter- wide and narrow band pass filter - wide and narrow band reject filter- All pass filter – Oscillators: Phase shift and Wien-bridge oscillators – square, triangular and sawtooth wave generators- Voltage controlled oscillator.

Text Book:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4PthP Ed. PHI, (Chap. 7)

Unit IV

Comparators and Converters (8 Hrs)

Basic comparator- Zero crossing detector- Schmitt Trigger – Comparator characteristics- Limitations of op-amp as comparators- Voltage to frequency and frequency to voltage converters - D/A and A/D converters- Peak detector – Sample and Hold circuit.

Text Book:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4PthP Edn. PHI. (TChap. 8)

IC555 Timer (3 Hrs)

IC555 Internal architecture, Applications IC565-PLL, Voltage regulator ICs 78XX and 79XX

Text Book:

1. Op-amps and linear integrated circuits R.A. Gayakwad 4PthP Edn. PHI. (Chap. 10)

Analog Communication (7 Hrs)

Review of analog modulation – Radio receivers – AM receivers – superhetrodyne receiver – detection and automatic gain control – communication receiver – FM receiver – phase discriminators – ratio detector – stereo FM reception.

Text Book:

1. Electronic Communication Systems, Kennedy & Davis 4PthPEd.TMH, (Chap. 6)

Reference Books:

1. Electronic Devices (Electron Flow Version), 9/E T T Thomas L. Floyd, Pearson

2. Fundamentals of Electronic Devices and Circuits 5PthP Ed. David A. Bell, Cambridge.

3. Electronic Communications Dennis Roddy and John Coolen, 4PthP Ed. Pearson.

4. Modern digital and analog communication systems, B.P. Lathi&Zhi Ding 4PthP Ed., Oxford University Press.

5. Linear Integrated Circuits and Op Amps, TS Bali, TMH

PH1P01 GENERAL PHYSICS PRACTICALS

(Minimum of 12 Experiments with Error analysis of the experiment is to be done)

1. Y, n, σ Cornu’s method (a) Elliptical fringes and (b) Hyperbolic fringes.

2. Absorption spectrum –$KMnO_4$ solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method

3. Frank and Hertz Experiment – determination of ionization potential.

4. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.

5. Resistivity of semiconductor specimen–Four Probe Method.

6. Band gap energy measurement of silicon.

7. Magnetic Susceptibility-Guoy's method / Quincke's method.

8. Michelson Interferometer - λ and $d\lambda$ / thickness of mica.

9. Ultrasonic-Acousto-optic technique-elastic property of a liquid.

10. B - H Curve-Hysteresis.

11. Oscillating Disc-Viscosity of a liquid.

12. e/m of the electron-Thomson's method.

15. Characteristic of a thermistor - Determination of the relevant parameters.

16. Dielectric constant of a non-polar liquid.

17. Dipole moment of an organic molecule (acetone).

18. Young's modulus of steel using the flexural vibrations of a bar.

19. Verification of Stefan's law and determination of Stefan's constant of radiation

20. Temperature dependence of a ceramic capacitor and verification of Curie-Wiess law

21. Experiments using GM counter- absorption co-efficient of beta rays in materials.

22. Multichannel analyzer for alpha energy determination.

23. Zeemann effect setup – measurement of Bohr magnetron

24. Photoelectric effect – determination of Plank's constant using excel or origin.

25. Magneto-optic effect (Faraday effect)- rotation of plane of polarization as a function of magnetic flux density.

26. Linear electro-optic effect (Pockels effect) – half wave voltage and variation of intensity with electric field.

27. Silicon diode as a temperature sensor.

29. Electrical and thermal conductivity of copper and determination of Lorentz number.

SEMESTER – II

PH2C05 MATHEMATICAL METHODS IN PHYSICS – II

Unit I

Complex Analysis (18 Hrs)

Functions of a complex variable - Analytic functions - Cauchy-Riemann equation - integration in a complex plane – Cauchy's theorem-deformation of contours - Cauchy's integral formula - Taylor and Laurent expansion- poles, residue and residue theorem – Cauchy's Principle value theorem - Evaluation of integrals.

Text Books:

1. Mathematical Physics, B.D. Gupta, VikasPub.House, New Delhi

2. Mathematical methods in Classical and Quantum Physics, T. Dass& S. K. Sharma, Universities Press (2009)

3. Introduction to Mathematical physics, Charlie Harper, PHI

Unit II

Integral Transforms (18 Hrs)

Introduction to Fourier series and Fourier integral form - Fourier transform - square wave, full wave rectifier and finite wave train – momentum representation of hydrogen atom ground state and harmonic oscillator. Laplace transform –inverse Laplace transform-properties and applications – Earth's nutation, LCR circuit, wave equation in a dispersive medium, damped, driven oscillator, solution of differential equations.

Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken&H.J. Weber 4 P th P Edition, Academic Press.

2. Mathematical Physics, H.K Dass& Dr. Rama Verma, S. Chand &Co.

Unit III

Group theory (18 Hrs)

Introductory definition and concepts of group - point group, cyclic group, homomorphism and isomorphism-classes, reducible and irreducible representations- Schur's Lemmas and Great Orthogonality theorem. Group character table- C2V, C3V and C4V groups, Lie group, concept of generators- rotation group SO(2), SO(3), Unitary Group SU(2) and SU(3) Homomorphism between SU(2) and SO(3) – Irreducible Representation of SU(2).

Text Books:

1. Elements of Group Theory for Physicists, A.W. Joshi, New Age India

2. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi. 3. Group theory-Schaum's series, Benjamin Baumslag& Bruce Chandler, MGH.

Unit IV

Partial Differential Equations (18 Hrs)

Characteristics and boundary conditions for partial differential equations.Nonlinear partial differential equations – separation of variables in Cartesian, cylindrical and spherical polar coordinates.Heat equation, Laplace's equation and Poisson's equation. Nonhomogeneous equation - Green's function - symmetry of Green's function - Green's function for Poisson equation, Laplace equation and Helmholtz equation - Application of Green's function in scattering problem

Text Books:

1. Mathematical Methods for Physicists, G.B. Arfken& H.J. Weber 4 P th P Edition, Academic Press.

2. Mathematical Physics, B.S Rajput, PragatiPrakashan

Reference Books:

(Given Under PH1C01)

PH2C06 QUANTUM MECHANICS – I

Unit I

Basics of Quantum Mechanics (14 Hrs)

Stern - Gerlach experiment leading to vector space concept, Dirac notation for state vectors- ket space, bra space, inner products - algebraic manipulation of operators – unitary operators, eigenkets and eigenvalues – Hermitian operators-concept of complete set-representation of an operator by square matrix – matrix elements of an operator - expectation values of Hermitian and anti-Hermitian operators – generalized uncertainty product — change of basis-orthonormal basis and unitary matrix, transformation matrixunitary equivalent observables-eigenkets of position-infinitesimal operator and its properties – linear momentum as generator of translation – canonical commutation relations – properties of wave function in position space and momentum space - relations between operator formalism and wave function formalism-momentum operator in position basis – momentum space wave function – computation of expectation values x, xP2P, p and pP2 Pfor a Gaussian wave packet.

Text Book:

1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education (Chapter 1)

Unit II

Quantum Dynamics (18Hrs)

Time evolution operator and its properties-Schrodinger equation for the time evolution operator - energy eigenkets - time dependence of expectation values - time energy uncertainty relation - Schrodinger picture and Heisenberg picture - behaviour of state kets and observables in Schrodinger picture and Heisenberg picture - Heisenberg equation of motion - Ehrenfest's theorem - time evolution of base kets - transition amplitude - energy eigenket and eigen values of a simple harmonic oscillator using creation and annihilation operators

Text Book:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 2)

Identical particles

Identity of particles - spin and statistics-Pauli's exclusion principle - Helium atom

Text Book:

1. Quantum Mechanics, V. K. Thankappan, New Age International, 1996, (Chapter 9)

Unit III

Angular momentum (20 Hrs)

Commutation relation between infinitesimal and rotationinfinitesimal rotations in quantum mechanics-fundamental commutation relations of angular momentum - rotation operator for spin ½ system - Pauli two component formalism - Pauli spin matrices - 2x2 matrix representation of rotation operator – commutation relations for JP 2 P , JBxB – eigenvalues of JP 2 P and JBx B- matrix elements of angular momentum operators - representation of the rotation operator – rotation matrix-properties of the rotation matrix-orbital angular momentum as a rotation generator - addition of angular momentum and spin angular momentum - addition of spin angular momenta and Clebsch-Gordon coefficients for two spin ½ particles

Text Book:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education,

Unit IV

Solutions of Schrodinger equation and Approximation Methods (20 Hrs)

Motion in a central potential - Hydrogen atom WKB approximation - WKB wave function –validity of the approximation - connection formula (proof not needed) potential well - barrier penetration variational methods - bound states – hydrogen molecule ion - stationary state perturbation theory - non degenerate case - anharmonic oscillator - degenerate case -applications - first order Stark effect and Zeeman effect in hydrogen

Text Book:

1. Quantum mechanics, V.K. Thankappan New Age International 1996 (Chapter 4, 8)
2. Quantum Mechanics, G Aruldhas, PHI, 2002, (Chapter 10)

Reference Books:

1. A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.
2. Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996
3. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
4. Quantum Mechanics, E. Merzbacher, John Wiley, 1996
5. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
6. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill
7. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
8. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.
9. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.

PH2C07 THERMODYNAMICS AND STATISTICAL MECHANICS

Unit I

Fundamental of Thermodynamics (10 Hrs)

Fundamental definitions – different aspects of equilibrium – functions of state – internal energy – reversible changes – enthalpy – heat capacities – reversible adiabatic changes in an ideal gas – second law of thermodynamics – the Carnot cycle - equivalence of the absolute and the perfect gas scale of temperature – definition of entropy- measuring the entropy – law of increase of entropy – calculations of the increase in the entropy in irreversible processes – the approach to equilibrium.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 1 and 2)

Foundations of Statistical Mechanics (8 Hrs)

Ideas of probability – classical probability – statistical probability – the axioms of probability theory – independent events – counting the number of events – statistics and distributions – basic ideas of statistical mechanics - definition of the quantum state of the system – simple model of spins on lattice sites – equations of state – the second law of thermodynamics.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 3 and 4)

Unit II

The Canonical Ensemble (12 Hrs)

A system in contact with a heat bath – the partition function – definition of the entropy in the canonical ensemble – the bridge to thermodynamics through partition function – condition for thermal equilibrium – thermodynamic quantities from partition function – case of a two level system – single particle in a one dimensional box – single particle in a three dimensional box – expression for heat and work – rotational energy levels for diatomic molecules – vibrational energy levels for diatomic molecules – factorizing the partition function – equipartition theorem – minimizing the free energy.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

Statistics of Identical Particles (4 Hrs)

Identical particles – symmetric and antisymmetricwavefunctions - bosons – fermions – calculating the partition function for identical particles – spin – identical particles localized on lattice sites.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 6)

Unit III

Maxwell Distribution and Planck's Distribution (12 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory – Planck's distribution – derivation of the Planck's distribution – the free energy – Einstein's model vibrations in a solid – Debye's model of vibrations in a solid.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7 and 8)

Grand Canonical Ensemble (8 Hrs)

Systems with variable number of particles – the condition for chemical equilibrium – the approach to chemical equilibrium – chemical potential – reactions – external chemical potential – grand canonical ensemble – partition function – adsorption of atoms on surface sites – grand potential.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley& M. Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 9)

Unit IV

Fermi and Bose Particles (6 Hrs)

Statistical mechanics of identical particles – thermodynamic properties of a Fermi gas – examples of Fermi systems – non-interacting Bose gas.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chapter 10)

Phase Transitions (12 Hrs)

Phases – thermodynamic potential – approximation – first order phase transition - Clapeyron equation phase separation – phase separation in mixtures – liquid gas system – Ising model – order parameter – Landau theory- symmetry breaking field – critical exponents.

Text Book:

1.Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2PndP Edn. 2007, Oxford University Press, Indian Edition, (Chaptr 11& 12)

Reference Books:

1. Statistical Mechanics, R.K. Pathria, & P.D. Beale, 2PndP Edn, B-H (Elsevier) (2004).
2. Introductory Statistical Physics, S.R.A. Salinas, Springer (2000).
3. Fundamentals of Statistical and Thermal Physics, F. Rief, McGraw Hill (1986).
4. Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).
5. Statistical Mechanics, Satyaprakash&Agarwal, KedarNath Ram Nath Pub. (2004).
6. Problems and solutions on Thermodynamics and Statistical mechanics, Yung Kuo Lim, World Scientific Pub. (1990)
7.Fundamentals of Statistical Mechanics, A.K. Dasgupta, New Central Book Agency Pub.(2005)
8. Statistical Mechanics: a survival guide, A.M. Glazer and J.S. Wark, Oxford University Press. (2001).

PH2C08 **CONDENSED MATTER PHYSICS**

Unit I

Elements of Crystal Structure (6 Hrs)

Review of crystal lattice fundamentals and interpretation of Bragg's equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity - atomic, geometrical and crystal structure factors- physical significance.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 8)

Free Electron Theory of Metals (12 Hrs)

Review of Drude-Lorentz model - electrons moving in a one dimensional potential well - three dimensional well - quantum state and degeneracy - density of states - Fermi-Dirac statistics - effect of temperature on FermiDirac distribution - electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 10)

Unit II

Band Theory of Metals (6 Hrs)

Bloch theorem - Kronig-Penney model - Brillouin zone construction of Brillouin zone in one and two dimensions – extended, reduced and periodic zone scheme of Brillouin zone (qualitative idea only) - effective mass of electron - nearly free electron model – conductors - semiconductors - insulators.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 11)

Band theory of semiconductors (10 Hrs)

Generation and recombination - minority carrier life-time - mobility of current carriers - drift and diffusion - general study of excess carrier movement- diffusion length.

Text Book:

1.Solid State Physics, S.O. Pillai, New Age International 6PthP Edn. 2010,(Chapter 10).

Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors - junction properties- metal-metal, metalsemiconductor and semiconductor-semiconductor junctions.

Ref. Text:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 13)

Unit III

Lattice Dynamics (14 Hrs)

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3PrdP Edn. Wiley India.(Chapter 4).

Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 7 &9)

Dielectric Properties of Solids (6 Hrs)

Review of basic terms and relations, ferroelectricity, hysteresis, dipole theory - Curie-Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6PthP Edn. 2010, (Chapter 11).

   Ferroelectric domain, antiferroelectricity and ferrielectricity.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2PndP Edn. 2010, (Chapter 14)

Unit IV

Magnetic properties of solids (10 hrs)

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism - spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6PthP Edn. 2010, (Chapter 9).

Superconductivity (4 Hrs)

Thermodynamics and electrodynamics of superconductors- BCS theory- flux quantization-single particle tunneling- Josephson superconductor tunneling- macroscopic quantum interference

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3PrdPEdn. Wiley India.(Chapter 12).

2. Solid State Physics, S.O. Pillai, New Age International 6PthP Edn. 2010, (Chapter 8).

Nanotechnology and Metamaterials (Qualitative) (4 Hrs)

Properties of metal, semiconductor, rare gas and molecular nanoclusters- superconducting fullerene- quantum confined materials-quantum wells, wires, dots and rings- metamaterials- grapheme

Text Book:

1.Introduction to Nanotechnology, Charles P Poole and Frank J Owens, Wiley India (Chapter 4, 5, 9)

Reference Books:

1. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11PthP Indian Reprint (2011).

2. Solid State Physics, R.L. Singhal, KedarNath Ram Nath& Co (1981)

3. Elementary Solid State Physics, M. Ali Omar, Pearson, 4PthP Indian Reprint (2004).

4. Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).

5. Elements of Solid State Physics, J. P. Srivastava, PHI (2004)

6. Solid State Physics, Dan Wei, Cengage Learning (2008)

7. Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)

PH2P02 ELECTRONICS PRACTICALS

(Minimum of 12 experiments should be done)

1. R C Coupled CE amplifier - Two stages with feedback - Frequency response and voltage gain.

2. Differential amplifiers using transistors and constant current source - Frequency response, CMRR.

3. Push-pull amplifier using complementary - symmetry transistorspower gain and frequency response.

4. R F amplifier - frequency response & band width - Effect of damping.

5. Voltage controlled oscillator using transistors.

6. Voltage controlled oscillator using IC 555

7. R F Oscillator - above 1 MHz frequency measurement.

8. Differential amplifier - using op-amp.

9. Active filters – low pass and high pass-first and second orderfrequency response and rolloff rate.

10. Band pass filter using single op-amp-frequency response and bandwidth.

11. Wein-bridge Oscillator – using op-amp with amplitude stabilization.

12. Op-amp-measurement of parameters such as open loop gain - offset voltage – open loop response. 13. Crystal Oscillator

14. RC phase shift oscillator

15. AM generation and demodulation

16. Solving differential equation using IC 741

17. Solving simultaneous equation using IC 741

18. Current to voltage and voltage to current converter (IC 741)

19.Temperature measurement using ADC and microprocessor.

20. Op-amp-triangular wave generator with specified amplitude.

21. µp - stepper motor control.

22. µp- measurement of analog voltage.

23. µp-Digital synthesis of wave form using D/A Converter.

24. Analog to digital and digital to analog converter ADC0800 & DAC0800

SEMESTER – III

PH3C09 **QUANTUM MECHANICS – II**

Unit I

Time Dependent Perturbation Theory (16 hrs)

Time dependent potentials - interaction picture - time evolution operator in interaction picture - time dependent perturbation theory - Dyson series – transition probability - constant perturbation - Fermi-Golden rule - harmonic perturbation - interaction with classical radiation field - absorption and stimulated emission - electric dipole approximation - photo electric effect – energy shift and decay width - sudden and adiabatic approximation

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 5)
2. Quantum mechanics – V. K. Thankappan New Age Int. Pub 1996 (Chapter 8)

Unit II

Scattering (18 hrs)

Asymptotic wave function and differential cross section, Born approximation, Yukawa potential, Rutherford scattering. The partial wave expansion, hard sphere scattering, S-wave scattering for the finite potential well, resonances - Ramsaur- Townsend effect

Text Book:

1. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books Pvt Ltd, MGH (Chapter 13)

Unit III

Relativistic Quantum Mechanics (18 hrs)

Need for relativistic wave equation - Klein-Gordon equation - Probability conservation - covariant notation - derivation of Dirac equation - conserved current representation - large and small components - approximate Hamiltonian for electrostatic problem - free particle at rest -plane wave solutions - gamma matrices - bilinear covariant – relativistic covariance of Dirac equation - angular momentum as constant of motion.

Text Book:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 3)

Unit IV

Elements of Field Theory (20 hrs)

Euler-Lagrange equation for fields - Hamiltonian formulation – functional derivatives -conservation laws for classical field theory - Noether’s theorem - Non relativistic quantum field theory - quantization rules for Bose particles, Fermi particles - relativistic quantum field theory - quantization of neutral Klein Gordon field - canonical quantization of Dirac field – plane wave expansion of field operator - positive definite Hamiltonian

Text Book

1. Field Quantization, W Greiner , J Reinhardt, Springer, (Chapter 2, 3, 4 & 5)
2. Quantum mechanics - V.K. Thankappan, New Age Int. Publishers

Reference Books:

(In addition to books given under PH2C06, the following books are also recommended)

1. Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta,1989
2. Quantum Field Theory, Claude Itzykson& Jean Bernard Zuber, MGH, 1986
3. Introduction to Quantum Field Theory, S.J. Chang, World Scientific, 1990
4. Quantum Field Theory, Franz Mandl& Graham. Shaw, Wiley 1990

PH3C10 COMPUTATIONAL PHYSICS

Unit I

Curve Fitting and Interpolation (20Hrs)

The least squares method for fitting a straight line, parabola, power and exponential curves with the help of principle of least square fit. Interpolation - Introduction to finite difference operators, Newton's forward and backward difference interpolation formulae, Lagrange’s interpolation formula, Newton's divided difference formula with error term, interpolation in two dimensions. Cubic spline interpolation end conditions. Statistical tests - ΨP2 P test and T-test.

Unit II

Numerical Differentiation and Integration (16 Hrs)

Numerical differentiation, errors in numerical differentiation, cubic spline method - finding maxima and minima of a tabulated function - Integration of a function with Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule and error associated with each. Romberg's integration, Gaussian integration method, Monte Carlo evaluation of integrals - numerical double integration

Unit III

Numerical Solution of Ordinary Differential Equations (20Hrs)

Euler method - modified Euler method and Runge - Kutta 4PthP order methods - adaptive step size R-K method, predictor - corrector methods - Milne's method, Adam-Mouton method. Numerical Solution of System of Equations Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss elimination method and Gauss-Jordan method to find inverse of a matrix.Power method and Jacobi's method to solve eigenvalue problems.

Unit IV

Numerical solutions of partial differential equations (16Hrs)

Elementary ideas and basic concepts in finite difference method, Schmidt Method, Crank - Nicholson method, Weighted average implicit method. Concept of stability.

Text Books:

1. Mathematical Methods, G. ShankerRao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.

2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

Reference Books:

1. An Introduction to Computational Physics, Tao Pang, Cambridge University Press
2. Numerical methods for scientific and Engineering computation M.K Jain,S.R.KIyengar, R.K. Jain, New Age International Publishers
3. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
4. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
5. . Numerical Mathematical Analysis, J.B. Scarborough, 4PthP Edn, 1958

3.3.3 BUNCH - C: MATERIAL SCIENCE

PH3EC1 **SOLID STATE PHYSICS**

Unit I

Crystals and Symmetry Properties (20 Hrs) Crystalline state – Anisotropy - Symmetry elements – Translational, Rotational, Reflection – Restrictions on Symmetry elements – Possible combinations of Rotational Symmetries- Crystal systems - 14 Bravais lattices. Stereographic projection and point groups – principles – Constructions - Construction with the Wulff net - Macroscopic Symmetry elements- Orthorhombic system- Tetragonal system- Cubic system - Hexagonal system - Trigonal system - Monoclinic system- Triclinic system - Laue groups - Space groups.

Unit II

Optical Properties and Crystal Lasers (16 Hrs)

Lattice vacancies – diffusion – colourcentres – F-centre and other centres in alkali halides – ionic conductivity – colour of crystals – excitons in molecular crystals – model of an ideal photoconductor – traps – space charge effects – experimental techniques – transit time excitation and emission Aicalf mechanism – model for thallium activated alkali halides - electroluminescence.

Lasers: Properties of laser beams - temporal coherence - spatial coherence – directionality – single mode operation - frequency stabilization - mode locking - Q-Switching - measurement of distance - Ruby laser - four-level solid state lasers - semiconductor lasers - Neodymium lasers (Nd:YAG, Nd:Glass) .

Unit III

Semiconductor crystals (18 Hrs)

Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration - impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions. Plasmons, Polaritons and Polarons: Dielectric function of the electron gas – plasmons - electrostatic screening- polaritons and the LST relation – electron - electron interaction - Fermi liquid - electron-phonon interaction - Polarons- Peierls instability of linear metals.

Unit IV

Imperfections and Dislocations (18 Hrs)

Types of imperfections in crystals - thermodynamic theory of atomic imperfections – experimental proof – diffusion mechanisms - atomic diffusion theory – experimental determination of diffusion constant – ionic conduction – shear strength of single crystals - slip and plastic deformations. Dislocations - Burgers vectors – edge and screw dislocations – motion of dislocation – climb - stress and strain fields of dislocation – forces acting on a dislocation – stress and strain fields of dislocation – forces acting on a dislocation – energy of dislocation – interaction – between dislocation densities – dislocation and crystal growth – Dislocation – Frank – Read mechanism - point defects - twinning.

Reference Books

1.Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley

2. Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI

3. Solid State Physics, A.J.Dekker, Macmillan, (1967).

4. Lasers Theory and Applications, K.Thyagarajan, A.K. Ghatak, Plenum Press

5. Lasers and Non-Linear Optics, B B Laud, New Age International.

6. Solid State Physics, S.L. Gupta and V.Kumar, PragatiPrakashan.

7. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.

8. Solid State Physics,J.S. Blakemore, W.B.Saunders& Co. Philadelphia.

9. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole (1976).

10. Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.

11. A short course in Solid State Physics, Vol. I, F.C Auluck, Thomson Press (INDIA) Ltd.

12. Crystalline Solids, Duncan McKie, Christine McKie, Wiley

PH3EC2 CRYSTAL GROWTH TECHNIQUES

Unit I

Crystal Growth phenomena (18 Hrs)

The historical development of crystal growth – significance of single crystals - crystal growth techniques - the chemical physics of crystal growth. Theories of nucleation - Gibb's Thompson equation for vapour, melt and solution- energy of formation of spherical nucleus- heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory- The Muller-Krumbhaar model.

Unit II

Crystal Growth from Melt and Solution Growth (18Hrs)

Growth from the melt - the Bridgmann technique – crystal pulling - Czochralski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil flame fusion technique. Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

Unit III

Vapour Growth and Epitaxial Growth (18 Hrs)

Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet. Advantages of epitaxial growth, epitaxial techniques - liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, chemical beam epitaxy and atomic layer epitaxy

Unit IV

Materials for Semiconductor Devices (18Hrs)

Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quaternary alloys. Semiconductor Devices - Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

Reference Books:

1. The Growth of Single Crystal, R.A. Laudise, Prentice Hall, NJ.

2. Crystal Growth: Principles and Progress , A.W. Vere, Plenum Press, NY.

3. Crystal Growth Processes and methods, P.S. Raghavan and P. Ramasamy, KRU Publications.

4. A Short course in Solid State Physics, Vol. I, F.C. Auluck, Thomson Press India Ltd.

5.Crystal Growth, B.R. Pamplin, Pergamon, (1980) 6. Crystal Growth in Gel, Heinz K Henish, Dover Publication

PH3P03 COMPUTATIONAL PHYSICS PRACTICALS

(Minimum of 12 Experiments should be done with C++ as the programming language)

1. Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.

2. Study the path of a projectile for different angles of projection. From graph find the variation in range and maximum height with angle of projection.

3. Study graphically the variation of magnetic field B(T) with critical temperature in superconductivity using the relationship $B(T) = B_0 [1 - (T/Tc)^2]$, for different substances.

4. Discuss the charging /discharging of a capacitor through an inductor and resistor, by plotting time – charge graphs for a) non oscillatory, b) critical) oscillatory charging.

5. Analyze a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.

6. Study the variation in phase relation between applied voltage and current of a series L.C.R circuit with given values of L C Find the resonant frequency and maximum current.

7. A set of observations of π meson disintegration is given. Fit the values to a graph based on appropriate theory and hence calculate life time τ of π mesons.

8. Draw graphs for radioactive disintegrations with different decay rates for different substances. Also calculate the half-life's in each case.

9. Half-life period of a Radium sample is 1620 years. Analytically calculate amount of radium remaining in a sample of 5gm after 1000 years. Verify your answer by plotting a graph between time of decay and amount of substance of the same sample.

10. Plot the trajectory of a α-particle in Rutherford scattering and determine the values of the impact parameter.

11. Draw the phase plots for the following systems. (i) A conservative case (simple pendulum) (ii) A dissipative case (damped pendulum) (iii) A nonlinear case (coupled pendulums).

12. Two masses mB1B and mB2B are connected to each other by a spring of spring constant k and the system is made to oscillate as a two coupled pendulum. . Plot the positions of the masses as a function of time.

13. Plot the motion of an electron in (i) in uniform electric field perpendicular to initial velocity (ii) uniform magnetic field at an angle with the velocity. and (iii) simultaneous electric and magnetic fields in perpendicular directions with different field strengths.

14. A proton is incident on a rectangular barrier, calculate the probability of transmission for fixed values of VB0 Band E (VB0 B> E) for the width of barrier ranges from 5 to 10 Fermi, and plot the same.

15. Generate the interference pattern in Young's double slit interference and study the variation of intensity with variation of distance of the screen from the slit.

16. Analyze the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference

17. Generate the pattern of electric field due to a point charge

18. Sketch the ground state wave function and corresponding probability distribution function for different values of dispalcements of the harmonic oscillator.

19. Gauss elimination method for solving a system of linear equations.

20. Solving a second order differential equation using 4PthP order Runge- Kutta method.

21. Finding the roots of a nonlinear equation by bisection method.

Reference Books:

1. Computational physics, An Introduction, R.C. Verma, P.K. Ahluwalia& K.C. Sharma, New Age India, Pvt. Ltd.

2. An Introduction to computational Physics, Tao Pang, Cambridge University Press.

3. Simulations for Solid State Physics: An Interactive Resource for Students and Teachers, R.H. Silsbee & J. Drager, Cambridge University Press.

4. Numerical Recipes: the Art of Scientific Computing, W.H. Press, B.P. Flannery, S.A. Teukolsky&W.T.Vettering, Cambridge University Press.

SEMESTER - IV

PH4C11 **ATOMIC AND MOLECULAR PHYSICS**

Unit I

Atomic Spectra (18 Hrs)

The hydrogen atom and the three quantum numbers n, l and mBl.B - electron spin - spectroscopic terms. Spin-orbit interaction, derivation of spin-orbit interaction energy, fine structure in sodium atom, selection rules.Landegfactor, normal and anomalous Zeeman effects, Paschen–Back effect and Stark effect in one electron system. L S and j j coupling schemes (vector diagram) - examples, derivation of interaction energy, Hund's rule, Lande interval rule. Hyperfine structure and width of spectral lines.(qualitative ideas only).

Text Book:

1. Spectroscopy, B.P. Straughan& S. Walker, Vol. 1, John Wiley & Sons

Unit II

Microwave and Infra Red Spectroscopy (18 Hrs)

Microwave Spectroscopy: Rotational spectra of diatomic molecules - intensity of spectral lines - effect of isotopic substitution. Non–rigid rotor - rotational spectra of polyatomic molecules - linear and symmetric top - Interpretation of rotational spectra. IR Spectroscopy: Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - influence of rotation on the spectra of polyatomic molecules - linear and symmetric top - analysis by IR technique - Fourier transform IR spectroscopy.

Text Books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, Tata McGraw Hill
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.

Unit III

Raman and Electronic Spectroscopy. (18 Hrs)

Raman Spectroscopy: Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - mutual exclusion principle - rotational fine structure - structure determination from Raman and IR spectroscopy. Non- linear Raman effects - hyper Raman effect - classical treatment - stimulated Raman effect - CARS, PARS - inverse Raman effect Electronic Spectroscopy: Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy and dissociation products - Rotational fine structure of electronic-vibrational transition - Fortrat parabola - Predissociation.

Text books:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH

2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.

3. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern

Unit IV

Spin Resonance Spectroscopy (18 Hrs)

NMR: Quantum mechanical and classical descriptions - Bloch equations - relaxation processes - chemical shift - spin–spin coupling - CW spectrometer - applications of NMR. ESR: Theory of ESR - thermal equilibrium and relaxation - g- factor - hyperfine structure -applications.Mossbauer spectroscopy: Mossbauer effect - recoilless emission and absorption - hyperfine interactions – chemical isomer shift - magnetic hyperfine and electronic quadrupole interactions - applications.

Text Book:

1. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.

2. Spectroscopy, B.P. Straughan& S. Walker, Vol. 1, John Wiley & Sons

Reference Books:

1. Introduction of Atomic Spectra, H.E. White, McGraw Hill

2. Spectroscopy (Vol. 2 & 3), B.P. Straughan& S. Walker, Science paperbacks 1976

3.Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977

4.Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill

5. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, VanNostard, London.

6. Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan

7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall.Vol. 1 & 2. 8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India

PH4C12 NUCLEAR AND PARTICLE PHYSICS

Unit I

Nuclear Properties and Force between Nucleons (18 Hrs)

Nuclear radius, mass and abundance of nuclides, nuclear binding energy, nuclear angular momentum and parity, nuclear electromagnetic moments, nuclear excited states Duetron, nucleon-nucleon scattering, proton-proton and neutron-neutron interactions, properties of nuclear forces, exchange force model

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 3&4)

Unit II

Nuclear Decay and Nuclear Reactions (18 Hrs)

Beta decay, energy release, Fermi theory, experimental tests, angular momentum and parity selection rules, Comparative half lives and forbidden decays, neutrino physics, non conservation of parity Types of reactions and conservation laws, energetics of nuclear reactions, isospin, Reaction cross sections, Coulomb scattering, nuclear scattering, scattering and reaction cross sections, compound-nucleus reactions, direct reactions, heavy ion reactions.

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 9&11)

Unit III

Nuclear Models, Fission and Fusion (18 Hrs)

Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula Characteristics of fission - energy in fission - fission and nuclear structure, Controlled fission reactions - Fission reactors. Fusion processes, Characteristics of fusion, Controlled fusion reactors

Text Book:

1. Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 5, 13 &14)

Unit IV

Particle Physics (18 Hrs)

Types of interactions between elementary particles, Hadrons and leptons- masses, spin, parity and decay structure. Quark model, confined quarks, coloured quarks, experimental evidences for quark model, quark-gluon interaction. Gell-Mann-Nishijima formula, symmetries and conservation laws, C, P and T invariance, applications of symmetry arguments to particle reactions, parity non-conservation in weak interactions. Grand unified theories.

Text Book:

1.Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 18)

2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House (Chapter 16)

Reference Books:

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)

2. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, NewDelhi, (1983).

3. The particle Hunters - Yuval Ne’eman&Yoramkirsh CUP, (1996)

4. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).

5. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).

6. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.

7. Nuclear Physics, I. Kaplan, 2Pnd PEdn, Narosa, New Delhi, (1989).

8. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).

9. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi, (1981).

10. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company

11. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York, (1971).

12. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, AddisonWesley, Tokyo, (1995).

13. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.

14. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer (2002)

15. Elementary Particles and Symmetries, L.H. Ryder, Gordon and Breach, Science Publishers, NY, 1986

PH4EC3 **NANOSTRUCTURES AND CHARACTERIZATION**

Unit I

Low Dimensional Structures (18hrs)

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications - infrared detectors - quantum dot lasers - superconductivity. Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) –Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches.

Unit II

Carbon Nanostructures (18hrs)

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters -Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties - Mechanical Properties - Applications of Carbon Nano Tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials - Mechanical Properties – Nano structured Multi layers -Electrical Properties - Porous Silicon - Metal Nano cluster - Composite Glasses.

Unit III

Thermal, Microscopic and Infrared Analysis (18 Hrs)

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation. Microscopy – Electron microscopy – Principles and instrumentation – resolution limit – scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM.Atomic force microscope – Instrumentation. IR spectrophotometers – Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy – Principles, Instrumentation and Applications. Microwave Spectroscopy -Instrumentation and Applications

Unit IV

Mass Spectrometry, Resonance Spectroscopy (18 Hrs)

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications. NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR – Instrumentation - Interpretation of ESR spectra - Applications.

Reference Books:

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)

2. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).

3. Instrumental methods of Chemical Analysis, G. Chatwal& Sham Anand, Himalaya

4. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.

5. Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.

6. Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.

7. Instrumental methods of chemical analysis, G W Ewing, MGH

8. Scanning Tunnelling Microscopy, R. Wiesendanger& H.J. Guntherodt, Springer

9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.

3.4 OPTIONAL ELECTIVE BUNCH

PH4OE1 OPTOELECTRONICS

Unit I

Semiconductor Science and Light Emitting Diodes (10 hrs)

Semiconductor energy bands - semiconductor statistics – extrinsic semiconductors – compensation doping – degenerate and non degenerate semiconductors – energy band diagrams in applied field - direct and indirect bandgap semiconductors, - p-n junction principles - open circuit- forward and reverse bias – depletion layer capacitance – recombination life time – p-n junction band diagram - open circuit - forward and reverse bias – light emitting diodes – principles - device structures - LED materials, heterojunction high intensity LEDs – double heterostructure - LED characteristics and LEDs for optical fiber communications - surface and edge emitting LEDs.

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson 2009, (Chapter 3)

Fiber Optics (10 Hrs)

Symmetric planar dielectric slab waveguide – waveguide condition – single and multimode waveguides – TE and TM modes – modal and waveguide dispersion in the planar waveguide – dispersion diagram – intermodal dispersion – intramodal dispersion – dispersion in single mode fibers – material dispersion – waveguide dispersion – chromatic dispersion – profile and polarization dispersion – dispersion flattened absorption and scattering – attenuation in optical fibers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 2)

Unit II

Laser Principles (10 hrs)

Laser oscillation conditions - diode laser principles - heterostructure laser diode – double heterostructure – stripe geometry – buried heterostructure – gain and index guiding - laser diode characteristics – laser diode equation - single frequency solid state lasers – distributed feedback –quantum well lasers - vertical cavity surface emitting laser - optical laser amplifiers.

Text Book:

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 4)

Laser Output Control (6 hrs)

Generation of high power pulses, Q-factor, Q-switching for giant pulses, methods of Q-switching, mode locking and techniques for mode locking.

Text Book:

1. Laser fundamentals, William T. Silfvast, CUP 2nd Edn. (2009), (Chapter 13)

Unit III

Photodetectors and Photovoltaics (18 hrs)

Principle of p-n junction photodiode - Ramo's theorem and external photocurrent - absorption coefficient and photodiode materials - quantum efficiency and responsivity - PIN-photodiode – avalanche photodiode – phototransistor - photoconductive detectors and photoconductive gain - noise in photo-detectors – noise in avalanche photodiode - solar energy spectrum - photovoltaic device principles – I-V characteristics - series resistance and equivalent circuit - temperature effects - solar cell materials, device and efficiencies

Text Book

1. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009), (Chapter 5 & 6)

Unit IV

Optoelectronic Modulators (10 Hrs)

Optical polarization, birefringence, retardation plates, electro-optic modulators – Pockels effect - longitudinal and transverse electro-optic modulators, Kerr effect, Magneto-optic effect, acousto-optic effect – Raman Nath and Bragg-types.

Text Books:

1. Fiber optics and Optoelectronics, R.P. Khare, Oxford University Press, (2004), (Chapter 9)

2. Optoelectronics: an Introduction, J. Wilson and J.F.B. Hawkes, PHI, (2000), (Chapter 3)

Non-linear optics(8 Hrs)

Wave propagation in an anisotropic crystal - polarization response of materials to light - second order non-linear optical processes - second harmonic generation - sum and frequency generation, optical parametric oscillation - third order non-linear optical processes - third harmonic generation - intensity dependent refractive index - self-focusing - non-linear optical materials, phase matching - angle tuning - saturable absorption - optical bistability - two photon absorption.

Text Book:

1.Laser fundamentals, William T. Silfvast, CUP 2nd Edn. 2009, (Chapter 16)

Reference Books:

1. Semiconductor optoelectronic devices: Pallab Bhattacharya, Pearson(2008)

2. Optoelectronics: An introduction to materials and devices, Jasprit Singh, McGraw Hill International Edn., (1996).

3. Optical waves in crystals: Propagation and Control of Laser Radiation, A. Yariv and P. Yeh, John Wiley and Sons Pub. (2003)

PH4PC4 MATERIAL SCIENCE PRACTICALS

1. Ultrasonic Interferometer – ultrasonic velocity in liquids

2. Ultrasonic Interferometer – Young's modulus and elastic constant of solids

3. Determination of dielectric constant

4. Determination of forbidden energy gap

5. Determination of Stephan's constant

6. Determination of Fermi energy of copper

7. Study of ionic conductivity in KCl / NaCl crystals

8.Thermo emf of bulk samples of metals (aluminium or copper)

9. Study of physical properties of crystals (specific heat,thermalexpansion,thermalconductivity,dielectric constant)

10. Study of variation of dielectric constant of a ferro electric material with temperature(barium titanate)

11. Study of variation of magnetic properties with composition of a ferrite specimen

12. Four probe method – energy gap

13. Energy gap of Ge or Si

14.Hall effect – Hall constant

15.Thin film coating by polimerisation

16.Measurement of thickness of a thin film

17.Study of dielectric properties of a thin film

18. Study of electrical properties of a thin film(sheet resistance)

19. Growth of single crystal from solution and the determination of its structural,electrical and optical properties (NaCl,KBr,KCl,NHB4BCl etc.)

20. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal

21. Observation of dislocation – etch pit method

22. Michelson Interferometer – Thickness of transparent film

23. X-ray diffraction – lattice constant

24. Optical absorption coefficient of thin films by filterphotometry

25. Temperature measurement with sensor interfaced to a PC or a microprocessor

26. ESR spectrometer – g factor

27. Beam profile of diode laser

28. Track width of a CD using laser beam

29. He – Ne laser- verification of Maluslaw , measurement of Brewster angle,refractive index of a material